

WHAT IS CLAIMED IS:

1. An internal combustion engine cooling system comprising:

5 a radiator that receives cooling water from an internal combustion engine, cools the cooling water and returns cooled cooling water into the internal combustion engine;

10 a coolant passage connecting the internal combustion engine and the radiator, and including an inlet passage through which the cooling water flows from the internal combustion engine into the radiator, and an outlet passage through which the cooling water flows from the radiator into the internal combustion engine;

15 a bypass passage connecting the inlet passage and the outlet passage to make the cooling water discharged from the internal combustion engine bypass the radiator;

20 a flow control valve placed at a junction of the outlet passage and the bypass passage to control radiator flow rate at which the cooling water flows through the radiator and bypass flow rate at which the cooling water flows through the bypass passage;

a water pump placed in the inlet or the outlet passage to circulate the cooling water through the internal combustion engine and the radiator;

25 a desired coolant temperature setting means for setting a normal desired coolant temperature of the cooling water flowing through the outlet passage; and

a coolant temperature control means for controlling

temperature of the cooling water flowing through the outlet passage on the basis of the desired coolant temperature set by the desired coolant temperature setting means,

wherein the desired coolant temperature setting means changes the desired coolant temperature according to operating condition of the internal combustion engine, traveling condition of a vehicle mounted with the internal combustion engine, and ambient condition.

2. The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature for an uphill traveling mode differently from the normal desired coolant temperature when the vehicle is traveling in the uphill traveling mode, and sets a desired coolant temperature, for a downhill traveling mode differently from the normal desired coolant temperature when the vehicle is traveling in the downhill traveling mode.

3. The internal combustion engine cooling system according to claim 2, wherein the desired coolant temperature setting means sets the desired coolant temperature to be lower than the normal desired coolant temperature when the vehicle is traveling in the uphill traveling mode.

4. The internal combustion engine cooling system according to claim 2, wherein the desired coolant temperature

setting means sets the desired coolant temperature to be higher than the normal desired coolant temperature when the vehicle is traveling in the downhill traveling mode.

5           5.    The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature for a transient traveling state differently from the normal desired coolant temperature when the vehicle is in the transient traveling  
10           state.

6.    The internal combustion engine cooling system according to claim 5, wherein:

15           the desired coolant temperature setting means sets a desired coolant temperature for a steady traveling state differently from the normal desired coolant temperature when the vehicle is in the steady traveling state; and

20           the desired coolant temperature setting means sets the desired coolant temperature to be lower than the normal desired coolant temperature when the vehicle is in the transient traveling state.

25           7.    The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature differently from the normal desired coolant temperature according to altitude level as the ambient condition.

8. The internal combustion engine cooling system according to claim 7, wherein the desired coolant temperature setting means decreases the desired coolant temperature below the normal desired coolant temperature with the increase of altitude.

9. The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature differently from the normal desired coolant temperature according to humidity as the ambient condition.

10. The internal combustion engine cooling system according to claim 9, wherein the desired coolant temperature setting means increases the desired coolant temperature beyond the normal desired coolant temperature as the humidity increases.

11.. The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature differently from the normal desired coolant temperature according to intake temperature as the ambient condition.

12. The internal combustion engine cooling system according to claim 11, wherein the desired coolant temperature

setting means decreases the desired coolant temperature below the normal desired coolant temperature as the intake temperature increases.

5           13. The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature differently from the normal desired coolant temperature according to a combustion mode in case the internal combustion engine is of  
10 a direct-injection type.

14. The internal combustion engine cooling system according to claim 13, wherein the desired coolant temperature setting means sets the desired coolant temperature to be higher  
15 than the normal desired coolant temperature in the case of a stratified-charge combustion mode.

15. The internal combustion engine cooling system according to claim 1, wherein the desired coolant temperature setting means sets a desired coolant temperature differently  
20 from a normal desired coolant temperature according to a combustion mode in case the internal combustion engine is of a lean-burn type.

25           16. The internal combustion engine cooling system according to claim 15, wherein the desired coolant temperature setting means sets a desired coolant temperature to be higher

than the normal desired coolant temperature for a stoichiometric combustion mode when the lean-burn internal combustion engine is operating in a lean-burn combustion mode.

5           17. An internal combustion engine cooling system including a flow control valve capable of controlling flow rate of cooling water flowing through a bypass passage bypassing a radiator, and a coolant temperature control means for controlling coolant temperature by controlling the flow control  
10 valve, the system comprising:

          a valve diagnosing means for diagnosing the flow control valve for abnormalities; and

          a heat generation rate reducing control means that  
15 executes a heat generation rate reducing control operation to reduce heat generation rate of the internal combustion engine when the valve diagnosing means determines that the flow control  
valve is in an abnormal condition.

20           18. The internal combustion engine cooling system according to claim 17 further comprising:

          an abnormality level determining means for determining  
abnormality level of the flow control valve among a plurality  
of abnormality levels when the valve diagnosing means  
determines that the flow control valve is in an abnormal  
25 condition,

          wherein the heat generation rate reducing control means sets control parameters and/or control quantity for the heat

generation rate reducing control operation according to the abnormality level determined by the valve diagnosing means.

5           19. The internal combustion engine cooling system according to claim 18, wherein the heat generation rate reducing control means does not execute the heat generation rate reducing control operation when the abnormality level of the flow control valve determined by the abnormality level determining means is below a predetermined abnormality level, even if the valve  
10 diagnosing means determines that the flow control valve is in an abnormal condition.

15           20. The internal combustion engine cooling system according to claim 17, wherein the heat generation rate reducing control means achieves the heat generation rate reducing control operation by using at least one of throttle opening limitation, fuel cutting, stratified-charge lean combustion, operating cylinder reduction and changing control quantity of  
20 a variable intake valve system and/or a variable exhaust valve system.

          21. The internal combustion engine cooling system according to claim 17 further comprising a coolant temperature measuring means;

25           wherein the coolant temperature control means controls the flow control valve so that a coolant temperature measured by the coolant temperature measuring means may be adjusted to

a desired coolant temperature, and

the valve diagnosing means compares a measured coolant temperature measured by the coolant temperature measuring means and the desired coolant temperature while the coolant temperature control means is in a coolant temperature control operation, and determines whether the flow control valve is in an abnormal condition on the basis of the result of comparison of the measured coolant temperature and the desired coolant temperature.

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22. The internal combustion engine cooling system according to claim 17, wherein the heat generation rate reducing means includes:

an abnormality level determining means for determining abnormality level of the flow control valve when it is determined that the flow control valve is in an abnormal condition;

a throttle control means for controlling flow rate of intake air flowing into each of cylinders of the internal combustion engine by adjusting throttle opening of a throttle valve placed in an intake passage of the internal combustion engine; and

an operating cylinder reducing control means for interrupting combustion in some of cylinders of the internal combustion engine,

wherein a throttle opening control operation and a operating cylinder reducing operation are carried out so that



heat generation rate of the internal combustion engine is reduced according to the abnormality level determined by the abnormality level determining means.

5           23.   The internal combustion engine cooling system according to claim 22, wherein throttle control means of the heat generation rate reducing means limits maximum throttle opening of the throttle valve to a predetermined first throttle opening and executes the operating cylinder reducing control operation when the abnormality level determining means determines that the flow control valve is at a high abnormality level, and the throttle control means limits maximum throttle opening of the throttle valve to a predetermined second throttle opening when the abnormality level determining means determines  
10           that the flow control valve is at a low abnormality level.  
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